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Abstract:

Mid-InfraRed (MIR) broadband SuperContinuum (SC) sources are desirable for applications such as spectroscopy and IR countermeasures due to their high spatial coherence and high power density over a broad bandwidth [1]. For this ZBLAN is interesting as it has low loss out to 4.5 μm [Fig. 1(a)]. Additionally, it has a material Zero Dispersion Wavelength (ZDW) around 1.6μm that allows for generating a broadband SC using commercially available Erbium (Er) lasers at 1550 nm. With the ZDW still being far away from 1550nm the initial work on ZBLAN SC employed an intermediate silica fiber to generate light past 1.6μm, which was then launched into the ZBLAN fiber for generation of a MIR-SC [2]. More recently ZBLAN fiber designs with ZDW close to 1550 nm are used that allow for formation of broadband Supercontinuum through direct pumping at 1550nm with very high pulse energy around $\approx$10μJ[3]. Here we optimize ZBLAN step-index fiber (SIF) having NA=0.30 for direct pumping that requires x100 less in pulse energy to generate an efficient MIR-SC. This we do by exploiting the strong and broadband Modulation Instability (MI) gain and combined with a local dip in the dispersion regime around 3.2 μm appearing for certain design, which greatly improves formation of SC even with standard commercial Er pulsed lasers.
The ZBLAN fibers are pumped with a P_0=10kW and T_{FWHM}=10ps Erbium laser with a rep. rate at 40MHz. The developed SC in ZBLAN fibers is seen in Figs. 2(b-d) for L=10m and D_c=7μm (b), L=10m and D_c=6μm (c), and L=15m and D_c=5.7μm (d). The Er pump is

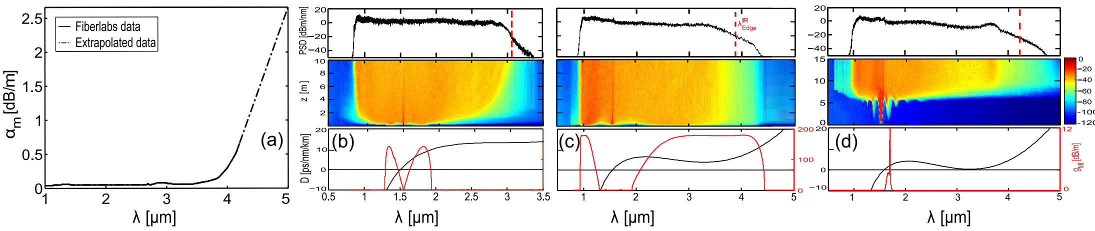

Figure 1: (a) ZBLAN material loss (solid) [FiberLabs. Inc.] with extrapolated dashed to 5μm for simulation. ZBLAN SC for fibers with NA=0.30, L=10m and D_c=7μm (b), L=10m and D_c=6μm (c), and L=15m and D_c=5.7μm (d). The developing SC down the fiber is seen in the middle, and the fiber dispersion (black) together with MI gain at input (red) is at the bottom for each fiber. Vertical red dashed line indicates -30 dB IR edge.

positioned in the anomalous dispersion for the 7μm fiber and 2.6nm in normal regime for the 6μm fiber, where both provide a strong and broad MI gain band (red) that efficiently broadens the pump. The D_c=5.7μm fiber positions the pump 34nm in normal dispersion regime, so no initial MI broadening is present at the fiber input. The pump undergoes broadening due to SPM and in 6m of fiber reaches the ZDW followed by efficient SC broadening due to the very small anomalous dispersion at 3.2μm. The the -30 dB IR edge for the three fibers considered are 3, 3.8 and 4.2 μm, respectively. Especially the 5.7 and 6μm cores are interesting; the former due to its very broad and strong MI gain band together with decreasing dispersion that that within 1m of fiber generates the majority of the MIR-SC, and the latter due to the very small anomalous dispersion that with the onset of SC generation likewise quickly provides a very broadband MIR-SC.
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